

## SMOKY HILL/SALINE RIVER BASIN TOTAL MAXIMUM DAILY LOAD

**Water Body/Assessment Unit: Smoky Hill River above Elkader**  
**Water Quality Impairment: Fluoride**

## 1. INTRODUCTION AND PROBLEM IDENTIFICATION

**Subbasin:** Smoky Hill Headwaters, North Fork Smoky Hill, Upper Smoky Hill & Ladder

**Counties:** Greeley, Logan, Scott, Sherman, Thomas, Wallace, and Wichita

<b>HUC 8:</b>	10260001	<b>HUC 11 (14):</b> <b>010</b> (090, 100, 110) (Figure 1) <b>020</b> (010, 020, 030) <b>030</b> (010, 020, 030, 040) <b>040</b> (010, 020, 030, 040, 050, 060)
	10260002	<b>010</b> (060, 070, 080, 090, 100, 110, 120) <b>030</b> (010, 020, 030, 040, 050, 060)
	10260003	<b>010</b> (010, 020, 030, 040, 050, 060) <b>020</b> (010, 020, 030, 040, 050, 060, 070, 080, 090) <b>030</b> (010, 020, 030) <b>040</b> (010, 020, 030, 040, 050, 060, 070, 080) <b>050</b> (010, 020, 030, 040, 050, 060, 070, 080)
	10260004	<b>010</b> (040, 050, 060, 070, 080) <b>020</b> (030, 040, 050, 060, 070, 080, 090) <b>030</b> (010, 020, 030, 040) <b>040</b> (010, 020, 030, 040) <b>050</b> (010, 020, 030, 040, 050, 060, 070, 080, 090)

**Ecoregion:** Western High Plains, Moderate Relief Rangeland (25c)  
Western High Plains, Flat to Rolling Cropland (25d)  
Central Great Plains, Rolling Plains and Breaks (27b)

**Drainage Area:** Approximately 3,555 square miles.

## **Smoky Hill River**

### **Main Stem Segments with Tributaries by HUC 8 and Watershed/Station Number:**

**HUC 10260003**

#### **Smoky Hill (Elkader) Station 224**

Smoky Hill R (21 - part)	<b>10260004</b> Ladder Cr (1)	Twin Butte (2)	
	Ladder Cr (3)	Chalk Cr (4)	
	Ladder Cr (5)	Unnamed Stream (6)	
	Ladder Cr (7)	Middle S.F. Ladder Cr (15)	
	Ladder Cr (8)	S. Ladder Cr (12)	Middle Ladder Cr (13)
			Middle N. Fk. Ladder Cr (17)
			Middle Ladder Cr (14)
	Ladder Cr (9)	Unnamed Stream (10)	
	Ladder Cr (11)		
Smoky Hill R (22)	Six mile Cr (23)		
Smoky Hill R (24)	West Spring Cr (33)		
	<b>10260002</b> N. Fk. Smoky Hill R (1)	Sand Cr (2)	
	N. Fk. Smoky Hill R. (3)	Sandy Cr (4)	
	N. Fk. Smoky Hill R. (5)	Turtle Cr (15)	
	N. Fk. Smoky Hill R. (6)		
<b>10260001</b> Smoky Hill R (1)	Lake Cr (2)	S. Fk. Lake Cr (18)	
Smoky Hill R (3)	Depperschmidt Draw (309)		
	Capper Draw (311)		
	Coon Cr (20)		
	Pond Cr (21)		
	Rose Cr (19)		
	Eagletail Cr (17)		
Smoky Hill R (4)	Goose Cr (5)		
Smoky Hill R (6)			
Smoky Hill R (8)	Unnamed Stream (9)		
Smoky Hill R (10)			

**Designated Uses:** Secondary Contact Recreation; Drinking Water; Food Procurement; Groundwater Recharge, Industrial Water Supply, Irrigation; Livestock Watering on Main Stem Segments, North Fork Smoky Hill River & Ladder Creek

(Elkader) Special Aquatic Life Support on segments 1, 3 Smoky Hill River & Ladder Creek; Expected Aquatic Life Support on remaining Main Stem Segments

No Irrigation or Stock water designated use on tributaries

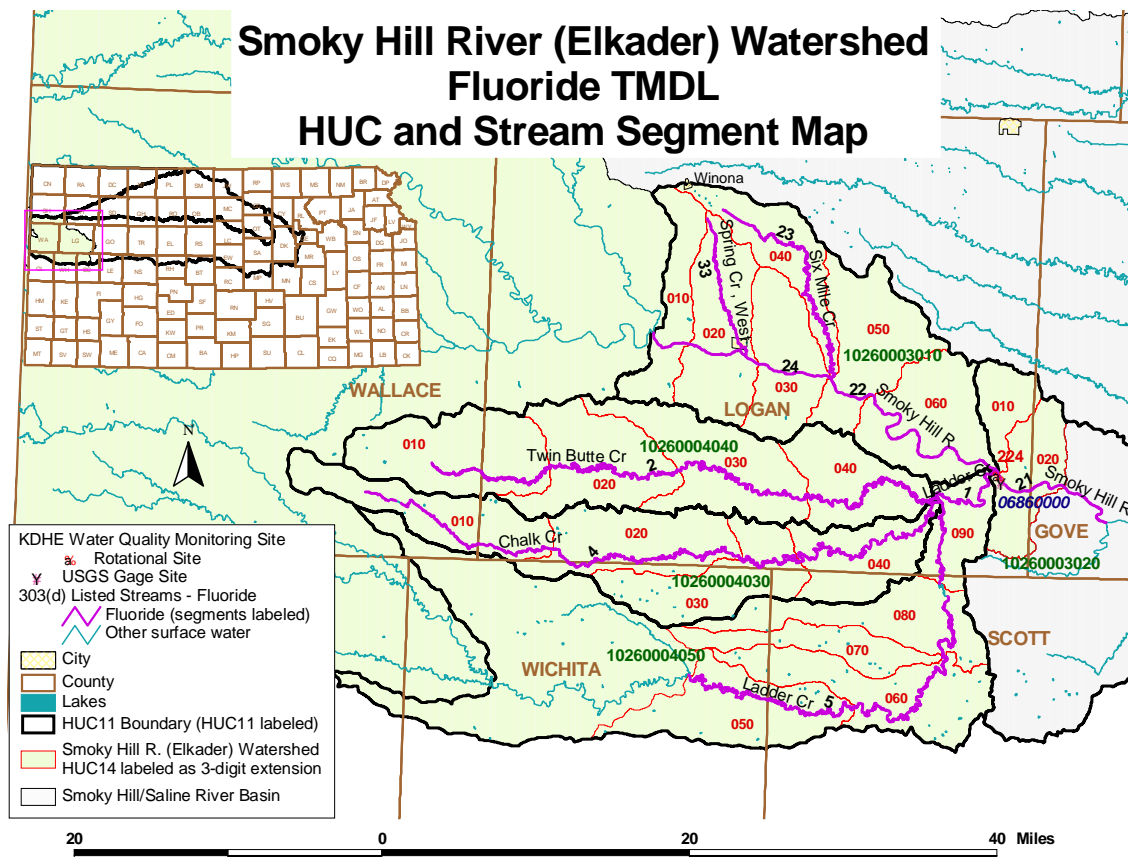
**2002 303(d) Listing:** Smoky Hill River above Elkader Watershed

**Impaired Use:** Irrigation, Domestic Water Supply and Stock water

**Water Quality Standard:** 1 mg/l for Irrigation; 2 mg/l for Domestic Water Supply and Stock water (KAR 28-16-28e(c)(1) & (3)(A))

In stream segments where background concentrations of naturally occurring substances, including chlorides and sulfates, exceed the domestic water supply criteria listed in table 1a in subsection (d), at ambient flow, due to intrusion of mineralized groundwater, the existing water quality shall be maintained, and the newly established numeric criteria for domestic water supply shall be the background concentration, as defined in K.A.R. 28-16-28b(e). Background concentrations shall be established using the methods outlined in the “Kansas implementation procedures: surface water quality standards,” as defined in K.A.R. 28-16-28b(ee), available upon request from the department. (K.A.R. 28-16-28e(c) (3)(B))

**Figure 1. Segment and HUCs in Smoky Hill Drainage above Elkader**



## 2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

### Stream Chemistry Monitoring Sites:

**Station 224 near Elkader (Smoky Hill River); Period of Record Used:** 1994 - 2004

**Flow Record:** Smoky Hill River at Elkader, KS (USGS Gage 06860000)

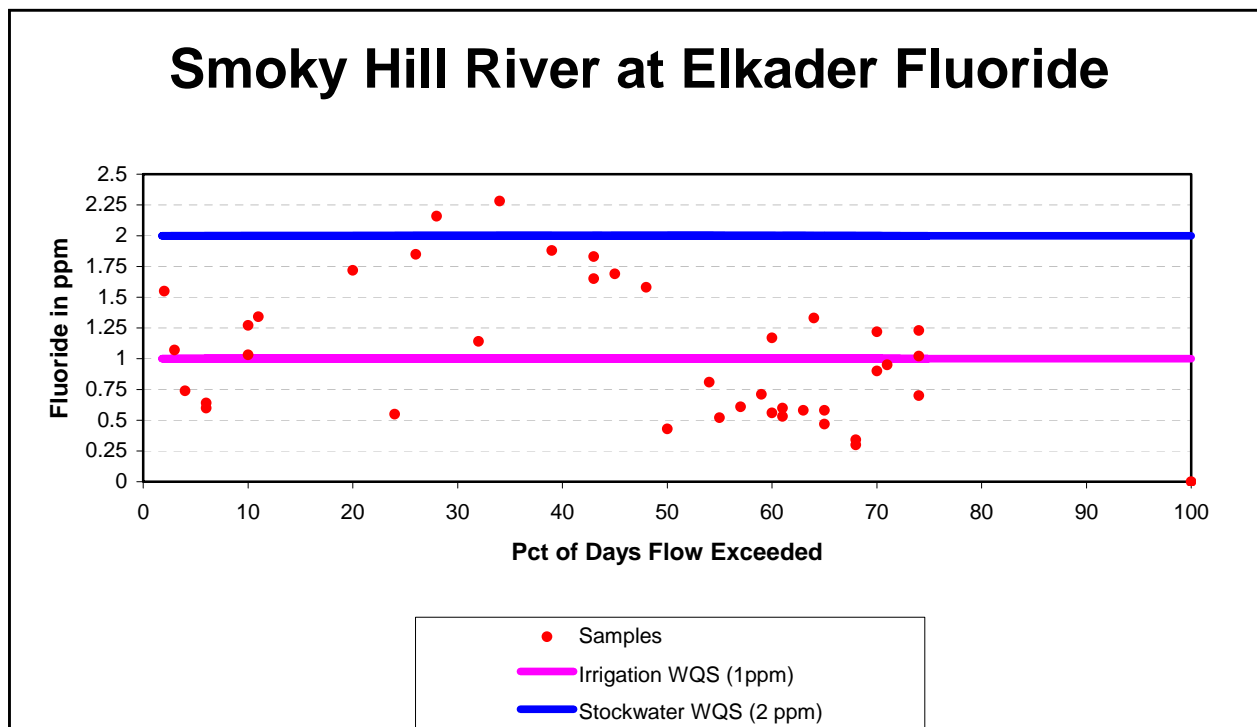
**Long Term Flow Conditions:** Median Flow = 0.5 cfs

The range and average fluoride concentration for Station 224 were 0.30-2.28 mg/l and 1.03 mg/l, respectively. Table 1 lists the basic statistics for fluoride at Station 224. Figure 2 displays the concentrations of fluoride over time at Station 224. Excursions from the criteria are seen at all flow conditions. The Smoky Hill River at Elkader ceases flowing at about 75% exceedance. As streamflow increases over the watershed, fluoride levels increase over the 2 mg/l criterion. Ladder Creek is the tributary with the steadiest flow, typically exceeding Elkader in duration of flow (Figure 3). The North Fork of the Smoky Hill River is often dry. Ladder Creek receives flow from the Ogallala Aquifer through outcroppings in the formation in Scott County. The ground water in the Ogallala tends to be higher in fluoride (1.5-2.5 mg/l) than other aquifers because of its high silica content from Tertiary age ash deposits. Therefore, Ladder Creek is likely to be a primary contributor of the flow and fluoride seen at Elkader.

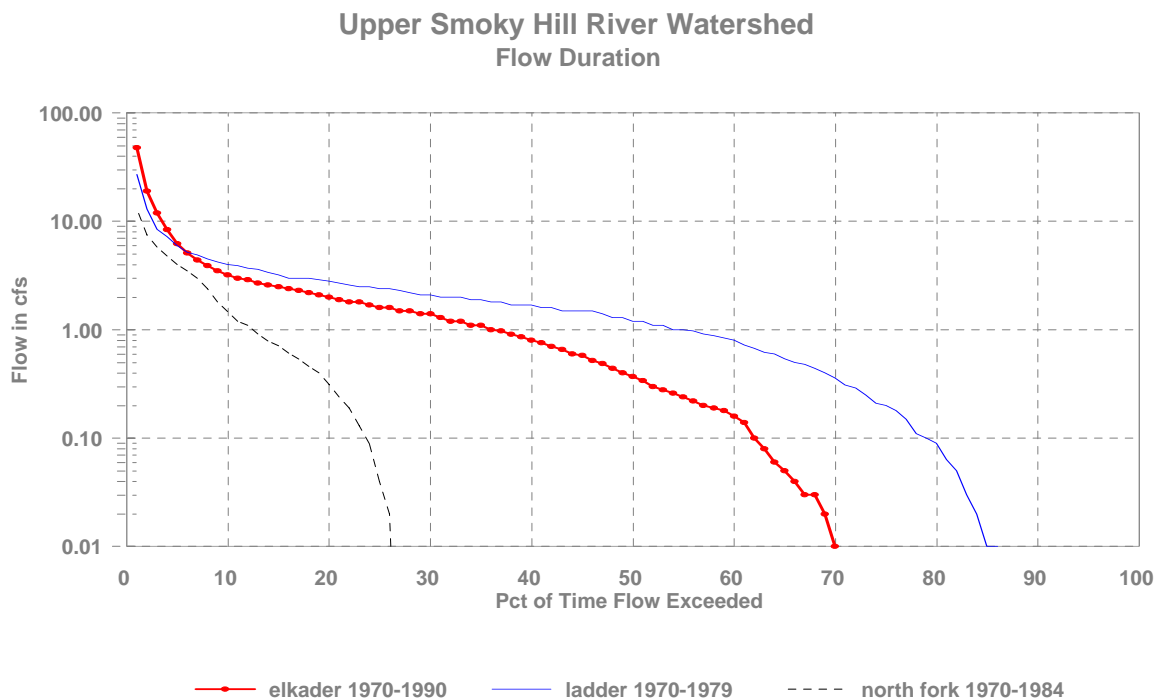
**Table 1. Basic Fluoride Statistics at Station 224**

Median Flow	Average F	Maximum F	# of Samples	# of Samples > 1 mg/l	# of Samples > 2 mg/l
0.37 cfs	1.05 mg/l	2.28 mg/l	40	20	2

**Figure 2. Smoky Hill River Fluoride and Flow Relationship**



**Figure 3. Flow Duration of Upper Smoky Hill River and Tributaries**



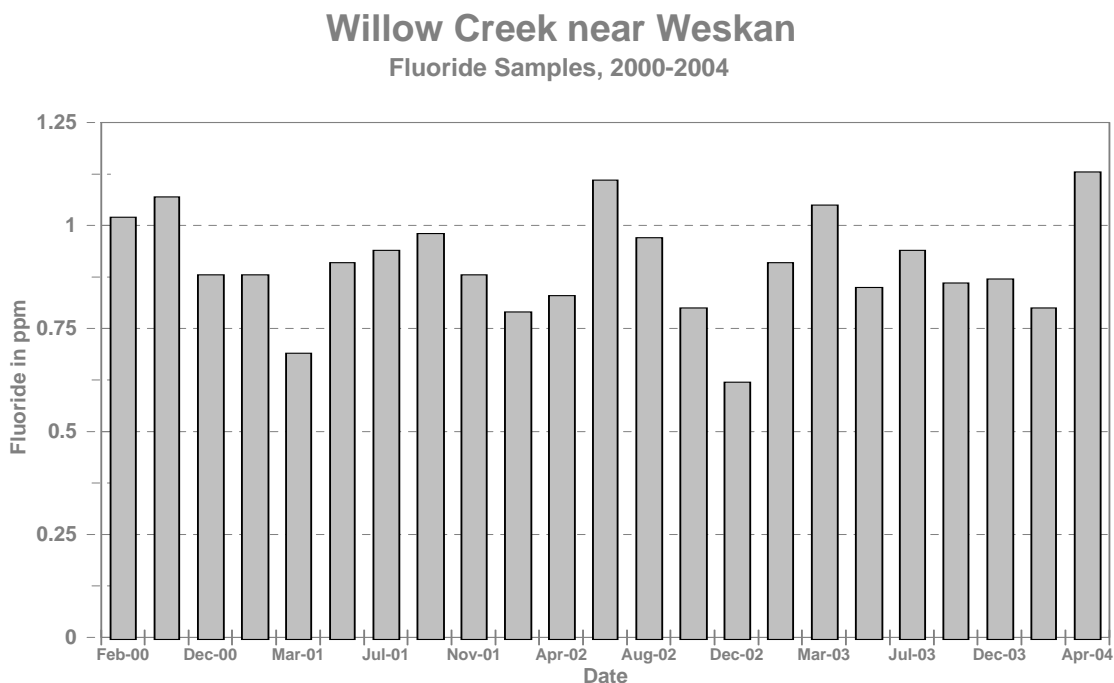
The incidence of high fluoride is not a recent phenomenon in the upper Smoky Hill River system. Samples taken by USGS in 1964, 1966 and 1967 indicate levels of fluoride above the 1 mg/l criterion. Table 2 shows the samples taken at three locations in the watershed. Generally, the relationship of increased fluoride at higher flows is notable, especially on Ladder Creek. The data also hint that the higher proportion of Elkader flow coming from Ladder Creek, the higher the fluoride concentrations seen at Elkader.

**Table 2. USGS Samples from Upper Smoky Hill River Drainage 1964-1967**

Stream and Location	Date	Flow	Fluoride
NF Smoky Hill nr McAllaster			
	Apr 66	1 cfs	1.00 mg/l
	Apr 67	0.3 cfs	1.10 mg/l
Ladder Creek below Scott Lake			
	Apr 64	2.2 cfs	1.8 mg/l
	Jun 64	5.8 cfs	1.3 mg/l
	Apr 66	7.0 cfs	2.1 mg/l
	Sep 66	2.4 cfs	0.9 mg/l
	Apr 67	6.1 cfs	2.2 mg/l
	Sep 67	0.5 cfs	2.0 mg/l
Smoky Hill nr Elkader			
	Apr 66	11 cfs	0.8 mg/l
	Sep 66	3.3 cfs	0.9 mg/l
	Apr 67	5.3 cfs	2.3 mg/l
	Sep 67	0.4 cfs	2.0 mg/l

Samples have been taken from Willow Creek near Weskan in the upper portion of the watershed. Sampling has occurred since 2000 on a bimonthly basis and was initiated because of the perennial flow, reference conditions and existence of a Topeka Shiner population in the otherwise ephemeral stream system. Fluoride levels are relatively high at this station, with five of the 23 samples exceeding the criterion (Figure 4).

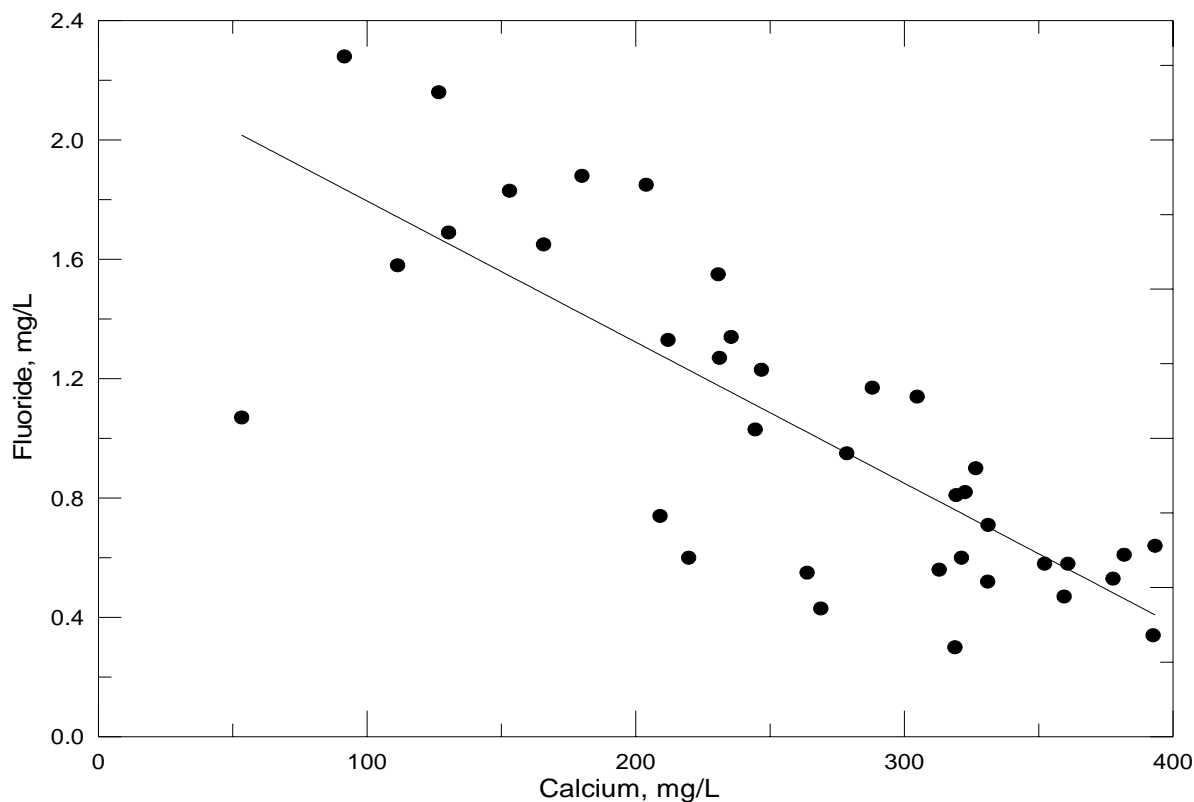
**Figure 4. Fluoride Concentrations on Willow Creek, 2000-2004**



Correlation analysis of the KDHE sampled data at Elkader indicates the statistically significant relationships with fluoride are all inverse relations. As fluoride levels rise, the concentrations of the other cations and anions decrease. This may be a coincidence of the inverse flow-concentration relationship for most cations and anions, except fluoride. It probably also reflects the small proportion of total dissolved solids made up by fluoride (average at Elkader for F:TDS – 1.05 mg/l: 1141 mg/l). Of significance is the inverse relationship between fluoride and calcium ( $r = -0.778$ ) (Figure 5). Higher levels of calcium will decrease fluoride in solution because the solubility of fluorite ( $\text{CaF}_2$ ) and apatite is easily exceeded, precipitating the mineral and removing the fluoride from the water.

Since loading capacity varies as a function of the flow present in the stream, this TMDL represents a continuum of desired loads over all flow conditions, rather than fixed at a single value. Sample data for the sampling sites were examined for each of the three defined seasons: Spring (Apr-Jun), Summer-Fall (Jul-Oct) and Winter (Nov-Mar). Table 3 shows the distribution of seasonal concentrations at Station 224. Most of the exceedances occurred in winter and spring, with the two exceedances over the 2 mg/l criterion occurring in February and March. The least number of exceedances happened in the summer months of July through October. While exceedances occurred across all flow ranges, there was a higher frequency of compliant

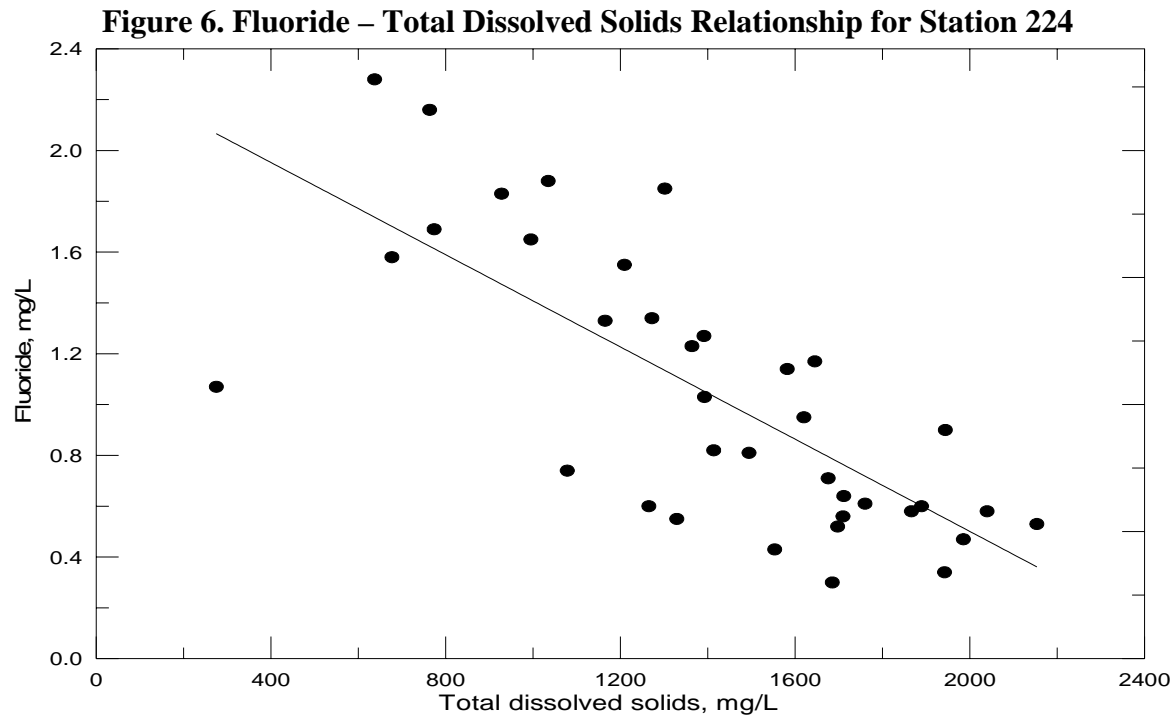
**Figure 5. Fluoride versus calcium concentration for the Smoky Hill River at Elkader.**



**Table 3. Distribution of Fluoride Concentrations over Seasons at Station 224**

Conc/Season	Winter	Spring	Summer-Fall
< 1 mg/l	7	4	9
1.1-1.5 mg/l	5	3	2
1.6-2 mg/l	1	6	1
> 2 mg/l	2	0	0

samples at flows less than median flow. This flow condition was prevalent in winter and summer. The primary source of fluoride is ground water discharging from the surrounding Ogallala-High Plains aquifer. Discharges from the aquifer at low flow, particularly in summer, are small; hence, fluoride concentrations tend to be below 1 mg/l. At the highest flows, overland runoff dilutes any contributions from the aquifer. But at intermediate flows with sufficient rainfall to raise water table levels, ground water discharge is predominant, particularly along tributaries such as Ladder Creek. Under these conditions, the higher fluoride concentrations will be seen. Similar to calcium, there is an inverse relationship with fluoride and Total Dissolved Solids (Figure 6). The Ogallala aquifer typically has ground water with a TDS content of less than 300 mg/l. The highest TDS and calcium levels are at low flow, where the calcium precipitates the fluoride out of solution. Taken in total, the fluoride concentrations seen at Station 224 are naturally driven.



A Load curve was established for the irrigation and stock water/domestic water supply criteria by multiplying the flow values along the curve by the applicable water quality criterion and converting the units to derive a load duration curve of pounds of fluoride per day. These load curves represent the TMDL since any point along the curve represents water quality for the standard at that flow. Historic excursions from the water quality standard are seen as plotted points above the load curve. Water quality standards are met for those points plotting below the load duration.

#### **Interim Endpoints of Water Quality (Implied Load Capacity) on the Upper Smoky Hill River**

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting irrigation, stock water and domestic water supply, although among the three uses, only stock watering could be considered persistent. This TMDL will, however, be phased. The current standard of 1 mg/L of fluoride was used to establish the TMDL. However, the Smoky Hill system is affected by the presence of fluoride-laden ground water from the discharge of the Ogallala-High Plains aquifer. As such, the upper Smoky Hill River has elevated fluoride levels throughout periods where flow is present and dominated by this natural source. The natural background of fluoride, consistently above 1 mg/l and occasionally over the stock water criterion of 2 mg/l makes achievement of the Standard.

Since the Standard is not consistently achievable because of natural contributions of the fluoride load, an alternative endpoint is needed.

Kansas Implementation Procedures for Surface Water allow for a numerical criterion based on



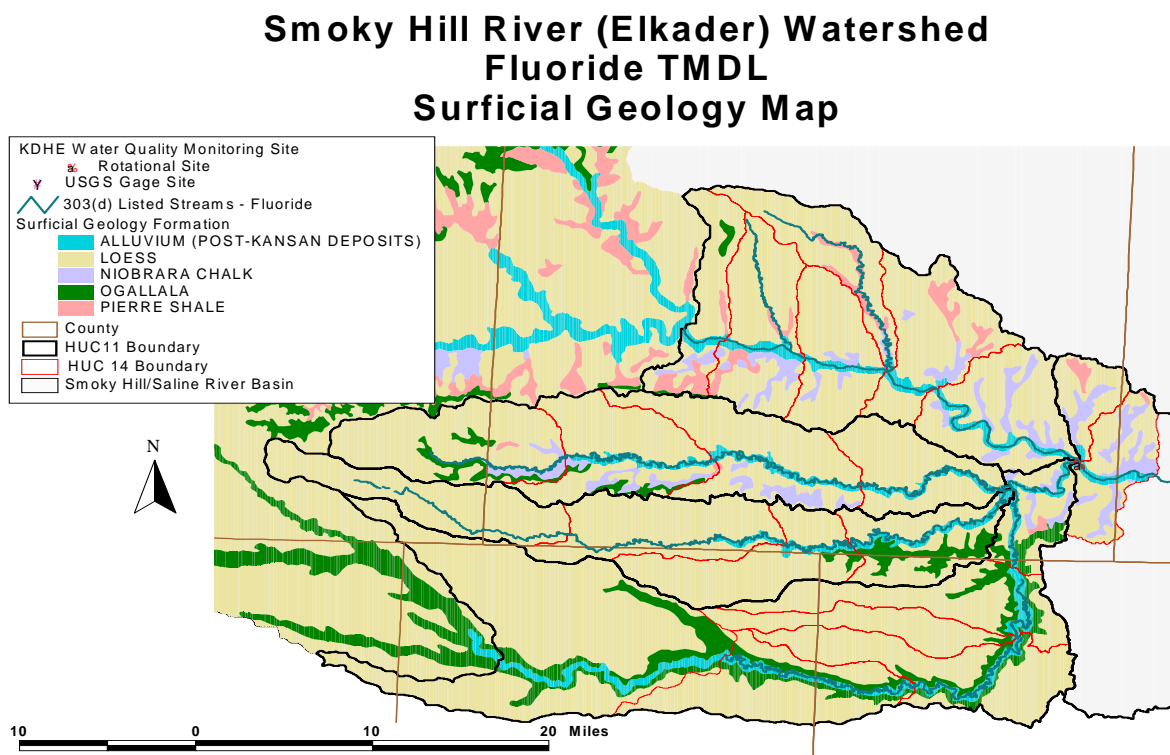
natural background to be established from samples taken at flows less than median in-stream flow. However, in this situation, the existing criterion is not achievable at higher flows, either. Therefore, there will be dual criteria; one criterion of 1.25 mg/l applied to flows less than median flow; and another criterion matching the 2 mg/l criterion and applied at flows greater than median flow. The break at median flow is logical since the precipitation conditions necessary to exceed median flow also supply any crop in production, thereby negating the need for stream water for irrigation. Achievement of these endpoints will help eliminate the occasional excursion over the greater criterion seen at higher flows.

Seasonal variation has been incorporated in this TMDL through the documentation of the seasonal pattern of elevated fluoride levels tied to seasonal streamflow patterns. Achievement of the endpoints indicate loads are within the loading capacity of the stream, water quality standards are attained and full support of the designated uses of the stream has been restored.

### **3. SOURCE INVENTORY AND ASSESSMENT**

**Geology:** The main contribution of fluoride to the Upper Smoky Hill stream system is ground water discharge from the Ogallala-High Plains aquifer to the tributaries of the river. There are numerous locations where the Ogallala outcrops in stream crossings, particularly along Ladder Creek (Figure 7). The higher fluoride concentration in the High Plains aquifer is generally associated with silica content and dissolution of volcanic ash deposits. Ground water in the Ogallala-High Plains aquifer in the drainages of Ladder Creek in Scott and Wichita Counties commonly contains fluoride levels over 1.5 mg/l, reaching up to 2.5 mg/l.

**Figure 7. Surface Geology of Upper Smoky Hill River Watershed**



**NPDES:** There are no permitted wastewater treatment facilities discharging to the Upper Smoky Hill River or its tributaries. Sharon Springs is the major municipality in the drainage basin with a population of 860 and operates a non-discharging system. The higher frequency of low fluoride concentrations at the lowest flows seen in the stream system suggest that if there were any effluent comprising the low flows, it would not be loading excessive fluoride into the streams

**Irrigation:** There is extensive irrigation with ground water the Upper Smoky Hill watershed, county totals for 2001 range from 7212 acre-feet for Logan County to 70,931 acre-feet for Wallace County (Figure 8). There is no surface water irrigation. The impact of the extensive irrigation has been to lower the ground water tables such that discharge from the aquifer to the stream system is discontinued. Because of the high evapotranspiration rates in Western Kansas, there is no return flow from irrigation. While there may be some concentration by evaporation in the streams, there also would be concentration of calcium that would precipitate fluoride out of solution. The incidence of higher fluoride levels in 1964-1967 suggests the exceedances of the criteria have been driven by natural source loading.

#### **4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY**

**Point and Non-point Sources:** Analysis of the flow distribution of fluoride concentrations indicates a natural non-point source of ground water discharge is the significant contributor to

the impairments of the Upper Smoky Hill River watershed. The relationship between the water table of the Ogallala-High Plains aquifer and the tributary stream channels influences the amount of fluoride seen at Station 224. The TMDL and allocations are displayed in the Load Duration curve of Figure 9.

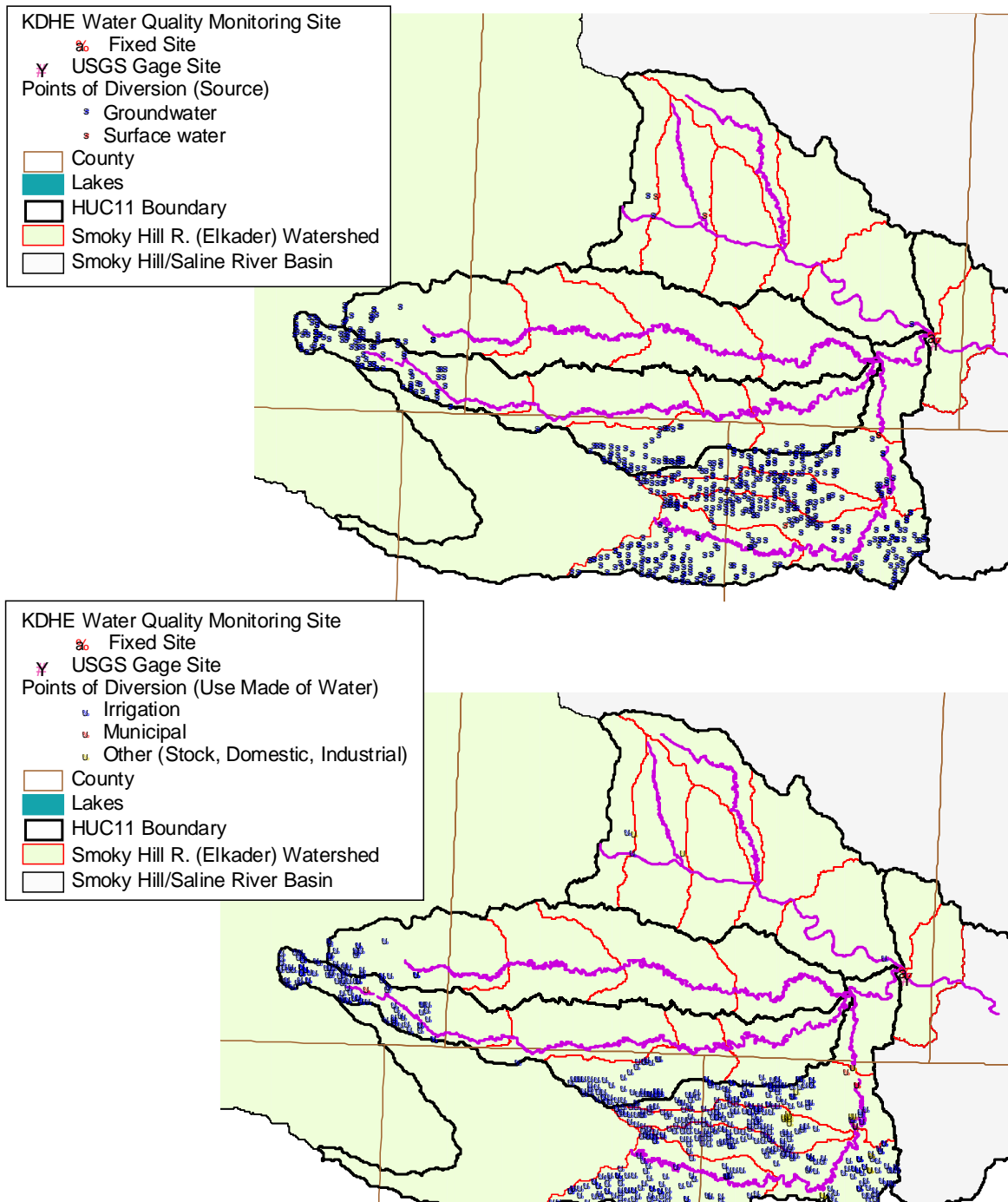
**Wasteload Allocation:** There are no facilities located in the watershed which discharge to the stream system, therefore, the initial Wasteload Allocation will be set at zero. Should a discharger appear in the future, an adjustment of allocation from the load allocation will need to occur to accommodate the wasteload added by this speculative new facility

**Load Allocations:** Much of the impaired condition is caused by natural background loadings. As indicated in Figure 9, the load allocations adjust to the ambient background concentrations seen as a result of flow conditions. At flows exceeded more than 50% of the time; the load allocation established at the criterion of 1 mg/l ranges from 0.05 to 1.84 pounds per day. The future criterion of 1.25 increases that range to 0.07 to 2.3 pounds per day. At flows greater than median flow, the existing criterion for stock water dominates and the range of load allocations between flows exceeded 50 to 1% is 4 to 518 pounds per day.

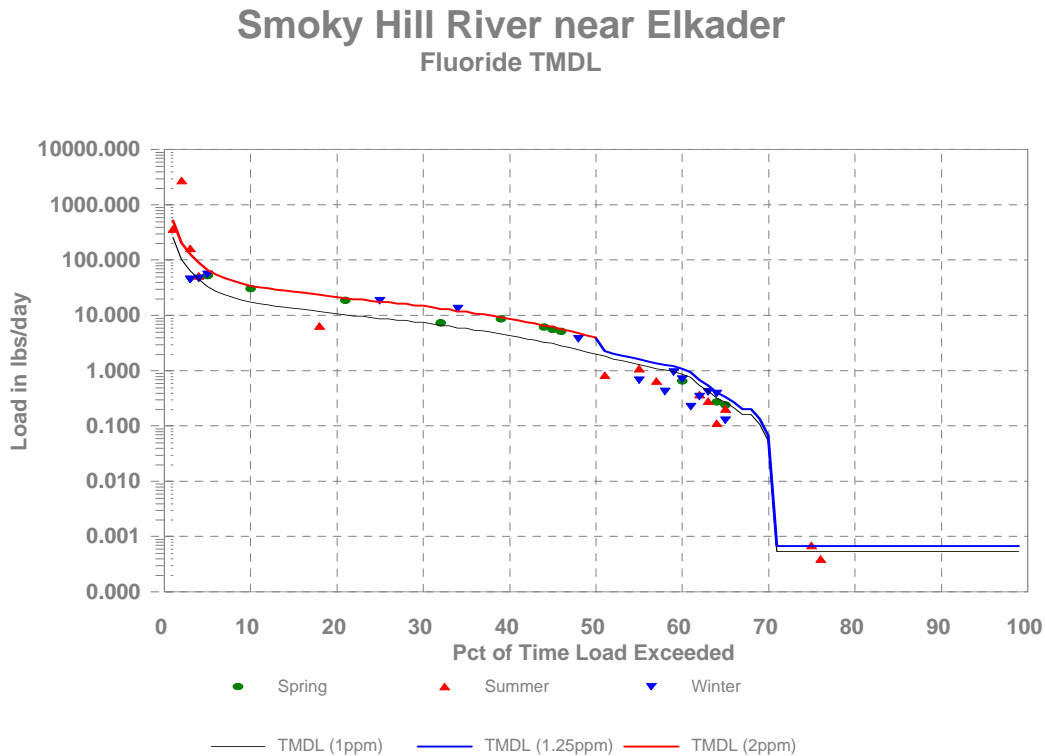
**Margin of Safety:** The margin of safety is implied by the lack of anthropogenic sources contributing fluoride to the streams at lower flows and lack of use made of surface water for irrigation in this watershed. Adherence to the 2 mg/l criterion ensures the stock water use of surface waters is maintained. Application of the 2 mg/l criterion at flows exceeding median flow presumes that such flows are generated by precipitation events that offset any need for irrigation. Application of the 1.25 mg/l criterion at lower flows protects stock watering during periods of most likely use.

Figure 8. Points of Diversion and Type of Water Use in Upper Smoky Hill Watershed

## Smoky Hill (Elkader) Watershed Points of Diversion



**Figure 9. Fluoride TMDL for Smoky Hill River near Elkader**



**State Water Plan Implementation Priority:** Because the fluoride impairment within the Upper Smoky Hill Watershed is primarily due to the natural discharge of ground water from the Ogallala-High Plains Aquifer, this TMDL will be a Low Priority for implementation.

**Unified Watershed Assessment Priority Ranking:** This TMDL addresses streams within the Smoky Hill Headwaters (HUC 8: 10260001); North Fork Smoky Hill (HUC 8: 10260002); Upper Smoky Hill (HUC 8: 10260003) and Ladder Creek (HUC 8: 10260004) watersheds with rankings over 65 (Low Priority for restoration).

**Priority HUC 11s:** Because of the natural geologic contribution of this impairment, no priority subwatersheds or stream segments will be identified.

## 5. IMPLEMENTATION

### Desired Implementation Activities

1. Monitor any anthropogenic contributions of fluoride loading to the streams.
2. Establish alternative background criterion.

## **Implementation Programs Guidance.**

### **Non-Point Source Pollution Technical Assistance - KDHE**

- a. Evaluate any potential anthropogenic activities that might contribute fluoride to the streams as part of the Cedar Bluff Lake Watershed Restoration and Protection Strategy.

### **Water Quality Standards and Assessment - KDHE**

- a. Establish background levels of fluoride for the river and tributaries.

**Time Frame for Implementation:** Development of a background level-based water quality standard should be accomplished with the 2004 water quality standards revision.

**Targeted Participants:** Primary participants for implementation will be KDHE.

**Milestone for 2008:** The year 2008 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from the streams covered by this TMDL should indicate no increase in average fluoride levels in the streams, particularly at higher flows. Should the case of impairment remain, additional source assessment, allocation and implementation activities will ensue.

**Delivery Agents:** The primary delivery agents for program participation will be the Kansas Department of Health and Environment.

### **Reasonable Assurances:**

**Authorities:** The following authorities may be used to direct activities in the watershed to reduce pollutants.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.
2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.
3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.
4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.
5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*.

6. The *Kansas Water Plan* and the Smoky Hill/Saline Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

**Funding:** The State Water Plan Fund annually generates \$16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Low Priority consideration.

**Effectiveness:** Minimal control can be exerted on natural contributions to loading at high flows, although lower flows can be protected against anthropogenic loading from point sources.

## 6. MONITORING

KDHE will continue to collect samples from Sites 224 and 724 on the Smoky Hill River near Elkader and on Willow Creek. Based on that sampling, the priority status will be evaluated in 2008 including application of numeric criterion based on background concentrations.

## 7. FEEDBACK

**Public Meetings:** Public meetings to discuss TMDLs in the Smoky Hill/Saline Basin were held January 7 and March 5, 2003 in Hays. An active Internet Web site was established at <http://www.kdhe.state.ks.us/tmdl/> to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Smoky Hill/Saline Basin.

**Public Hearing:** A Public Hearing on the TMDLs of the Smoky Hill/Saline Basin was held in Hays on June 2, 2003.

**Basin Advisory Committee:** The Smoky Hill/Saline Basin Advisory Committee met to discuss the TMDLs in the basin on October 3, 2002, January 7, March 5, and June 2, 2003.

**Discussion with Interest Groups:** Meetings to discuss TMDLs with interest groups include:  
Smoky Hill River Task Force: January 22, February 27, April 16, and May 28, 2003

**Milestone Evaluation:** In 2008, evaluation will be made as to the degree of implementation that has occurred within the watershed. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

**Consideration for 303(d) Delisting:** The streams will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2008-2012. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period,

consideration for delisting, desired endpoints of this TMDL and implementation activities might be adjusted accordingly.

**Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process:** Under the current version of the Continuing Planning Process, the next anticipated revision would come in 2005, which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2004-2008.

### **Bibliography**

- 1. Whittemore, Don; July 7, 2004 Memo on Fluoride Source assessment and analysis for the Fluoride TMDL for the Upper Smoky Hill River.**